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IS 15578 (2005): Code of practice for handling and usage of
gas mixtures [CHD 6: Industrial Gases]
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भारतीय मानक

गैस मिश्रणों के प्रहस्तन व उपयोग की रीति संहिता

Indian Standard

CODE OF PRACTICE FOR HANDLING AND USAGE OF GAS MIXTURES

ICS 71.100.20

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

July 2005

Price Group 3

Industrial Gases Sectional Committee, CHD 6

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Industrial Gases Sectional Committee had been approved by the Chemical Division Council.

Theoretically, the range of gas mixtures and the number of components which can be filled into cylinders is infinite. The number of commonly used mixtures continues to grow with every passing day and presently, over 25 000 different mixtures with up to 30 components in each cylinder are in use, limited only by the laws of science.

In general terms, properties of gas mixtures are directly related to the individual components that constitute the mixture, taking into consideration the concentrations of each component within the mixture. There are basically three types of mixtures, namely, gas-gas mixtures, gas-liquid mixtures and liquid-liquid mixtures. Each of these mixtures may fall under the category of inert, oxidant, radio-active, flammable, pyrophoric, corrosive, poisonous, etc.

For certain critical applications, it is not sufficient to know only the individual components present in a gas mixture but it is also necessary to determine what their synergistic effects are likely to be. This makes it necessary to know certain basic features of individual gases in order to handle their mixtures safely, which may include the physical and chemical properties of gas mixtures being handled and of their individual components; the necessary general precautions and the hazards associated with gas mixtures and additional precautions specific to their individual components; and the necessary emergency first-aid.

This standard has been formulated to assist both, the users and the manufacturers, of gas mixtures by prescribing certain guidelines regarding safe handling and usage of gas mixtures.

At present there is no ISO Standard on the subject.

The composition of the Committee responsible for formulating this standard is given at Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*).' The number of significant places retained in the rounded off value shall be the same as that of the specified value in this standard.

Indian Standard

CODE OF PRACTICE FOR HANDLING AND USAGE OF GAS MIXTURES

1 SCOPE

This standard prescribes guidelines and codes of practice for safe handling and usage of gas mixtures.

2 REFERENCES

The standards listed below contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revisions, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
4379 : 1981	Identification of contents of industrial gas cylinder (*first revision*)
7062 : 1973	Glossary of terms relating to gas industry

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 7062 shall apply.

4 CATEGORIES OF GAS MIXTURES

4.1 Gas-Gas Mixtures

Gas-gas mixtures are mixtures in which the two gases form homogeneous mixture in the gas phase at room temperature and under nominal cylinder pressures. However, in a very small number of cases, exposure of cylinders containing gas-gas mixtures to temperatures less than 10° C may affect the mixture composition only if partial pressure of a component in the mixture approaches vapour pressure of the component at the cylinder temperature. Any mixture component liquefied under these conditions will remix in the gas phase if the cylinder is stored horizontally at 15° C or above for 24 h before use. Additionally, rolling the cylinder will increase the rate of mixing and ensure homogeneity.

4.2 Gas-Liquid Mixtures

Gas-liquid mixtures exist in variable concentrations depending upon temperature and pressure of the constituents as well as the total pressure. These mixtures within a cylinder exist in two forms, namely, the gas-dissolved-in-liquid and the gas-gas resultant mixture over the liquid.

4.3 Liquid-Liquid Mixtures

In liquid-liquid mixtures, the two components exist together in liquid phase within the cylinder and like in the case of the gas-liquid mixtures, have a vapour phase above the mixture which is quite different in composition from the mixture. Removal of vapour phase in liquid-liquid mixture causes fractionation of the mixture and changes concentrations of the individual components in the mixture. In case of liquid-liquid mixtures, full length eductor (dip) tubes are normally provided so that the mixture can be withdrawn and a relatively uniform mixture is attainable throughout the withdrawal of the contents.

5 CLASSIFICATION

The categories of mixtures in **4** may also be classified according to the nature of hazard associated with them, as prescribed in **5.1** to **5.9**.

5.1 Flammable Mixtures

Flammable mixtures, when mixed with air, oxygen or other oxidants burn or explode upon ignition, depending upon the degree of confinement. Every flammable mixture has a gas-in-oxidant concentration range within the limits of which the gas may be ignited. Flammable ranges are expressed in terms of air at ambient temperature and atmospheric pressure. A change in temperature, pressure or oxidant concentration may vary the flammable range considerably. Mixtures above and below the flammable range do not ignite. As a precaution in handling flammable gases, care must be taken to eliminate all possible sources of ignition through proper design installation of approved electrical systems and restriction of smoking and use of open flames, fires or welding. An explosive meter or similar devices may be used to determine the existence of a flammable mixture in areas of suspected leakages.

5.2 Oxidant Mixtures

A number of mixtures, although non-flammable, may initiate and support combustion. Materials that burn in air, burn more vigorously and/or explosively in oxygen and certain other oxidants. All possible sources of ignition must be eliminated while handling oxidants. Oxidants must not be stored with combustible materials. Oils, greases or other combustible substances must not come in contact with cylinders or equipment used in oxidant service.

5.3 Corrosive Mixtures

Corrosive mixtures are mixtures that corrode and erode materials which they come in contact with, such as metals, fabrics, human tissue, etc. Some mixtures, though not corrosive in their anhydrous form, become corrosive in the presence of moisture. Special care must be taken when selecting the proper construction material for equipment in which corrosive mixtures are to be handled.

5.4 Irritant Mixtures

The mixtures that cause inflammatory reactions after immediate, prolonged or repeated contact are sometimes called irritant mixtures. Protective clothing and equipment must be used to minimize exposure to corrosive and irritant mixtures.

5.5 Pyrophoric Mixtures

Flammable mixtures which burn spontaneously upon exposure to air are called pyrophoric mixtures.

5.6 Inert/Asphyxiant Mixtures

Mixtures, which do not react with other materials under the normal conditions of temperature and pressure, are classified as inert. If released in a confined area, these mixtures may displace oxygen content of air below the level necessary to sustain life. Therefore, adequate ventilation and monitoring of oxygen content of confined areas should be carried out to minimize such a possibility.

5.7 Anesthetic Mixtures

Mixtures, which, when inhaled cause loss of consciousness without other symptoms, are called anesthetic gas.

5.8 High Pressure Mixtures

Though not an inherent property of any gas or mixture, a sudden release of pressure may cause serious damage to personnel or equipment by propelling a cylinder or whipping a line. Factors that are to be considered while choosing construction materials and designing handling systems are temperature and pressure of the mixture, and possibility of pressure build-up in the system.

5.9 Cryogenic Mixture

Mixtures having very low boiling points are stored as liquids in insulated vacuum jacketed dewars or insulated pressurised cylinders. Contact with these liquids causes burning due to the freezing of skin tissue by the rapidly evaporating liquid. Also, the liquid produces a large volume of gas upon vaporization in inadequately ventilated areas, except in the case of oxygen. This may decrease the oxygen content of the air below the level necessary to sustain life. Adequate ventilation, monitoring of oxygen content of confined areas and use of protective clothing minimize the hazards.

6 HANDLING OF MIXTURES

6.1 Filling of Mixtures in Cylinders

In the case of gas-gas mixtures, the cylinders are generally filled to their normal working pressure. However, the presence of a component having a low vapour pressure may necessitate filling the cylinder to a planned reduced pressure, usually restricted to vapour pressure of the component at specified filling temperature. In case of gas-liquid and liquid-liquid mixtures, cylinder pressure is dependent upon the combined vapour pressures of the liquid components. Where the final developed pressure is insufficient for liquid withdrawal, cylinders are pressurized with an inert gas, usually helium, to about 14 to 15 kg/cm^2.

6.1.1 The filling accuracy is dependent upon following factors:

a) Cylinder size,
b) Molecular mass of components,
c) Concentrations of various individual components, and
d) Balance gas used.

As a general rule, the gravimetric method of filling cylinders gives higher accuracy in filling.

6.1.2 In case when reactive individual components in a mixture are blended with an inert balance gas in a steel cylinder, the concentration that the cylinder delivers can vary with temperature, time and pressure. The instability of mixtures may be caused by a number of factors but is partially a function of gas absorption and reaction with cylinder walls. However, reaction with the cylinder wall material and adsorption can be reduced by the use of aluminium cylinders or treating the inner walls of the steel cylinders with special coatings and with compatible valves.

6.2 Cylinder Contents

The volume of mixture in a cylinder is usually quoted at 15° C and 1 013.25 millibar (one atmosphere). Exact content is dependent on the combined effects of individual components, compressibilities. Wherever possible, the volume takes compressibilities into account. However, it is more practical to give nominal gas contents assuming ideal gas behaviour. Nominal volumes are calculated excluding a residual pressure of one atmosphere.

6.3 Mixture Cylinder Identification

6.3.1 The body of the cylinder shall be painted with major component colour code in accordance with IS 4379 with red band on shoulder for inflammable gas and yellow band on shoulder for toxic gas. Where both inflammable and toxic gases are present in the mixture, red band shall be on upper shoulder next to the valve and yellow on lower shoulder. These bands shall be used, no matter how small the hazardous component concentration may be. In addition to colour coding, the cylinder shall be stencilled giving the name and formula of each component.

6.3.2 The manufacturer of mixtures shall provide physiological data of each component and their antidote in case of inadvertent accidents by inhalation, skin contact or otherwise, besides giving complete instructions about safe handling and storage in normal usage.

6.3.3 The buyer besides giving usual information about name, address, dispatch instructions, etc, shall clearly specify the grade of the mixture. It shall be clearly mentioned if third-party certification is required and whether any impurities or specific contaminants are to be analyzed. The cylinder size and the number shall also be mentioned.

7 AVAILABILITY AND USES OF MIXTURES

7.1 Availability

7.1.1 Availability of mixtures depends upon the particular method of manufacture and consumer requirements. The descriptions and specifications for mixtures are generally given in terms of the blending accuracy and/or analytical tolerances which are prescribed as applicable to particular mixture. These mixtures are generally expressed in terms of volume/volume percent for gases and mass/mass percent for liquids.

7.1.2 The requirements and specifications range from very general (for common industrial applications) to very stringent (for certain critical applications). The exact specification for given mixture may include only the mixture composition or may also include the extent of various impurities present and their acceptable tolerance levels. This again is dependent upon the specific consumer requirements and is governed by the manufacturing capabilities available.

7.1.3 Certified mixtures are produced volumetrically and are analyzed to a tolerance within range of ± 5 percent. Uncertified mixtures are prepared in exactly the same manner as certified gas mixtures but are analyzed to less stringent tolerances.

7.1.3.1 As a general rule gravimetric method will give higher accuracy in filling ± 0.5 to 1.0 percent of component or ± 2 VPM absolute, whichever is greater. Volumetric mixtures tolerances largely depend on component concentration. Higher tolerances are allowed for lower concentrations and *vice-versa*. For 10 VPM to 1 percent component level, typical tolerance may be ± 10 percent of minor component but if the component level is 1 to 50 percent, tolerance may be ± 5 percent. The actual analytical tolerance shall depend upon nature of the mixture and analytical techniques employed. It could be ± 1 to ± 2 percent for primary mixtures and ±2 to ±5 percent for certified mixtures.

7.2 Uses

7.2.1 Gaseous mixtures which are required for specific processes are normally chosen for their physical and chemical properties rather than the analytical accuracy of the mixture. Mixtures of gases are either used to reduce toxicity or inflammability of a highly active material or to modify the physical properties of a pure material by mixing it with other materials.

7.2.2 Mixtures of gases and/or liquid in cylinders provide convenient packages for a wide variety of uses, some of which are prescribed from **7.2.2.1** to **7.2.2.2.**

7.2.2.1 *Analytical instruments*

Pure gases and mixtures are used for the operation and/or calibration of analytical instruments. Zero gases (which are usually pure materials but are certified to contain negligible or known concentration of a component of interest) are used for flame ionization detector instruments and require gases of low hydrocarbon content to achieve maximum sensitivity. Zero air is used both to zero the instrument and to provide an oxidant of low hydrocarbon content for operation of the analyzer. Span gases, which usually contain a minor component of interest of a known concentration level, permit the analytical device at a value corresponding to that concentration. Fuel gas is used in instruments, such as those with flame ionization detectors, which require the supply of fuel gas in addition to certain physical properties of diluents. A mixture of 40 percent hydrogen in helium is common.

7.2.2.2 *Sterilizing*

Dilution of ethylene oxide, such as 12 percent with fluorocarbon 12 or 10 to 20 percent ethylene oxide with carbon dioxide are commonly used in sterilizing.

7.2.2.3 *Medical applications*

A low concentration of carbon monoxide in air is used for lung diffusion tests. A typical mixture could contain 0.28 percent of carbon monoxide, 14.00 percent of helium and the balance air. Various percentage mixtures of carbon dioxide in oxygen are used for blood gas analyzer calibration. Krypton 85 and xenon 133 are used in air mixtures to monitor the flow of blood through heart and brain. Laser gas mixtures containing carbon dioxide, nitrogen and helium are used for surgical operations carried out using lasers. Besides a wide range of gas mixtures are used to meet the demand for culture growth. For aerobic growth, 4 percent carbon dioxide in oxygen is usual while for anaerobic growth 10 percent carbon dioxide, 10 percent hydrogen and 80 percent nitrogen is used. Cyclopropane, nitrous oxide and certain other chemically active gases are used separately and as mixtures for anesthesia.

7.2.2.4 *Exhaust emission control gas mixtures*

These are usually low concentration mixtures of carbon monoxide, carbon dioxide, nitric oxide, nitrogen oxide, hexane or propane in nitrogen. Such mixtures are usually supplied in specially treated cylinders or aluminium cylinders to ensure stability of mixture.

7.2.2.5 *Pollution control*

Increasing awareness of the need to control and understand atmospheric pollution has prompted the gas industry to produce a complete supply and service package offering high accuracy calibration gas mixtures. The active component of such mixtures is usually sulphur dioxide, nitrogen dioxide (balance air only), methyl mercaptan, hydrogen sulphide or carbonyl sulphide in ppm range in air or other suitable carrier gases.

7.2.2.6 *Nuclear counter gases*

A mixture of 0.95 percent isobutane in helium and 1.3 percent butane in helium are used as Geiger-counter gas. Mixture of 4 percent isobutane in helium and 10 percent methane in argon are used in proportion in counter gases. Propane and helium mixtures are also used in this category.

Electronic component manufacture requires gases which include low level of dopants such as arsine, phosphine, diborane and in others hydrogen, helium, argon or nitrogen are used for making silicon semiconductors. Highly purified ammonia and its mixtures are used for nitriding. Silane, either pure or in mixture, is used for silicon deposition. Gas mixtures, similar to the ones above but with higher percentage levels of arsine and phosphine, are commonly used in manufacture of gallium semiconductors.

7.2.2.7 *Welding and industrial gas mixtures*

Argon-nitrogen, argon-oxygen, argon-carbon dioxide and argon-hydrogen are common welding gas mixtures. Nitrogen-hydrogen is used as forming gas mixture, while 70 to 75 percent helium is used with argon for helium welding mixtures.

7.2.2.8 *Fumigating*

Methyl bromide and ethylene oxide are used in fumigating.

7.2.2.9 *Chilling*

Refrigerants such as methyl chloride and mixtures of fluorocarbons are used for chilling.

7.2.2.10 *Explosive meter calibration*

A range of methane-air mixtures, blended and analyzed with extreme accuracy, are used throughout the world for calibration of many different types of explosive meters.

7.2.2.11 *Hydrocarbon propellant mixtures*

Propellant mixtures of hydrocarbons are usually blended to customers' vapour pressure requirements. The product is usually required to be odour free and should not leave any residue on evaporation.

7.2.2.12 *Lamp and valve industry*

Lighting industry uses a number of gas mixtures, for example, argon-nitrogen, neon-argon, krypton-argon and krypton-argon-nitrogen mixtures with moisture and oxygen, each less than 2 VPM. These mixtures are used for filament lamps and methyl bromide-krypton and hydrogen bromide-nitrogen mixtures are used in halogen lamps.

7.2.2.13 *Metallurgical application*

Hydrogen-nitrogen mixtures are used as annealing gas. In degassing non-ferrous alloys argon-chlorine and argon-freon mixtures are used to reduce hydrogen inclusions.

7.2.2.14 *Leak detection*

A low percentage of helium, halocarbon 12, or sulphur hexaflouride is used in air or nitrogen for leak detection. Krypton 85 is also used in a suitable carrier gas depending upon the type of application.

7.2.2.15 *Radio-active gas mixtures*

Krypton 85, tritium, and carbon 14 are commonly added in traces to a number of gases and gas mixtures for various specific applications.

7.2.2.16 *Special carrier gases*

Carrier gases are specially produced for instrumentation, where purity of the carrier gas is of major importance and impurities such as oxygen, moisture, hydrocarbons are reduced to a minimum to ensure long detector life and flat base line response. Typical examples of special carrier gases include spark chamber mixtures (helium-neon), electron capture flow gas - (argon- methane, hydrogen-helium, etc). FID mixtures have a total hydrocarbon content of less than 1 VPM.

7.2.2.17 *Simulated fuel gases*

Simulated fuel gases and mixtures are used to accurately reflect fuel burning characteristics of the gas being tested or other similar requirements. Also used commonly as reference standard.

7.2.2.18 *X-ray fluorescence spectroscopy*

Mixtures containing small amounts of butane in a mixture of helium and neon are used in X-ray fluorescence spectroscopy.

7.2.2.19 *Catalyst addition*

Nitrogen oxides and boron triflouride in nitrogen are used for catalyst addition.

7.2.2.20 *Laser mixtures*

The carbon dioxide laser is finding a considerable number of industrial and medical uses. Typical applications being date marking and coding, engraving and scribing, profile and hole cutting, welding and laser surgery. A typical mixture could include 7.0 percent carbon dioxide, 13.0 percent nitrogen and 80.0 percent helium. Excimer lasers, typically, consist of halogen donor, usually HCl or fluorine, a rare gas buffer and an inert gas diluent (normally helium). Sealed beam lasers contain xenon, carbon dioxide or carbon monoxide, nitrogen and helium. These are normally used for general research.

7.2.2.21 *Moisture measurement and monitoring*

An excess of moisture in certain processes can give rise to plant damage and production delays. Accurate routine indication of moisture levels can be a useful quality control procedure. These mixture carry known amount of moisture in balance inert gas for moisture measurement instrumentation.

7.2.2.22 *Food atmosphere packaging mixture*

Controlled atmosphere modification has rapidly become an accepted packaging technique for extending shelf life of a wide range of products including meat, poultry and fish. For meat, 11 percent nitrogen, 20 percent carbon dioxide and 60 percent oxygen is typically used; while for poultry, a mixture of 20 percent oxygen, 30 percent nitrogen and 50 percent carbon dioxide is used. For fishes, same gases are used but percentages vary depending upon the type of fish.

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Industrial Gases Sectional Committee, CHD 6

Organization	*Representative(s)*
Praxair India Pvt Ltd, Bangalore	Shri R. S. Dhulkhed (*Chairman*)
All India Industrial Gases Manufactuerers Association, New Delhi	Dr P. L. Bhatia Shri B. N. Qanungo (*Alternate*)
Bharat Heavy Electricals Ltd, Hyderabad	Shri N. V. S. Ramani Shri A. Rajamohan (*Alternate*)
Central Electronics Ltd, Ghazibabad	Shri M. I. Alam
Department of Electronics, New Delhi	Dr U. C. Pandey
Department of Industrial Development, New Delhi	Shri P. K. Jain Shri N. C. Tiwari (*Alternate*)
Gujarat State Fertilizer Corporation Ltd, Vadodara	Shri M. C. Shah Shri R. C. Mathur (*Alternate*)
BOC India Ltd, Kolkata	Shri P. Amarnath
Industrial Oxygen Co Ltd, Mumbai	Shri R. R. Singanporia
Sylvania & Laxman Ltd, New Delhi	Shri S. K. Kapoor Shri Naveen Sikka (*Alternate*)
Mohan Meakin Ltd, Ghaziabad	Dr E. K. Jayanarayanan
Ministry of Defence (DGQA), Kanpur	Shri Y. V. Vailure Shri Sujit Ghosh (*Alternate*)
National Test House, Kolkata	Dr B. B. Pal
Rashtriya Chemicals & Fertilizers Ltd, Mumbai	Dr R. N. Trivedi
Steel Authority of India, New Delhi	Shri A. Nagarajan Shri S. G. K. Murthy (*Alternate*)
The Asiatic Oxygen and Acetylene Co Ltd, Kolkata	Shri B. N. Sinha
The Industrial Gases Ltd, Kolkata	Shri T. Garg Shri L. R. Garg (*Alternate*)
Indian Space Research Organization, Shriharikota	Representative
Ordnance Factory, Bhandara	Dr S. K. Deshmukh Shri V. Srinivasan (*Alternate*)
Chief Controller of Explosives, Nagpur	Shri R. H. Bhalekar Shri S. K. Bhardwaj (*Alternate*)
Semi Conductor Complex Ltd, Punjab	Shri S. S. N. Prasad
Mahalasa Gases & Chemicals Pvt Ltd, Bangalore	Shri A. N. Prabhu Prof. M. G. Subba Rao (*Alternate*)
Steel Furnace Association of India), Surat	Shri M. K. Gupta
National Physical Laboratory, New Delhi	Representative
Association of Automobiles Manufacturers of India, New Delhi	Representative
Everest Kanto, Mumbai	Representative
BIS Directorate General	Dr U. C. Srivastava, Director & Head (CHD) [Representing Director General (*Ex-officio Member*)]

Member Secretary

Shri P. Ghosh
Director (CHD), BIS

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